Optical Properties of Glass
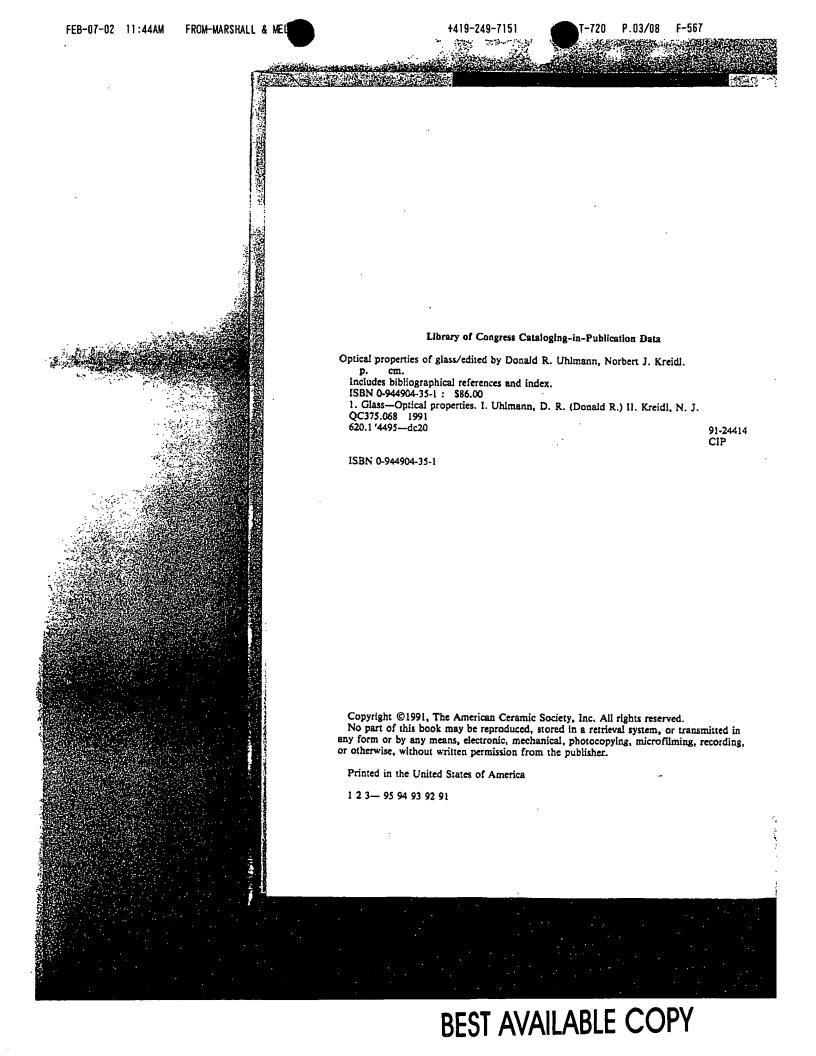
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A comparison of the valence vibration bands for Si–O (9 μm), B–O (7.5 μm), and P–O (10.5 μm) agrees with Kreidl et al.'s[4] finding that the replacement of SiO_2 by B_2O_3 causes a negative, that by P_2O_5 a positive deviation of the dispersion from the normal straight line.

Change of Dispersion by the Incorporation of Added Absorption Centers: Käs[6] investigated the changes in dispersion on incorporation of absorption centers (λ_a) in the ir and uv. Since "normal" glasses generally absorb at λ_a below 0.3 μm, added centers of absorption were chosen at $\lambda \approx 0.35$ μm, that is, above 0.3 μm to affect dispersion, but below 0.4 μm to avoid coloration. The selection of suitable ions is based on ligand field theory. The following ions possess absorption bands between $\lambda_0 = 0.3$ and 0.4.

Ion	Coordination	Absorption Band
Fe^{3+}	6 and 4	0.38
Ti^{4+}	6	0.37
V^{5+}	6	0.32
Cr^{6+}	4	0.36
Ag^0		0.34

Glasses may be doped with the ions, Ag^0 can be obtained by irradiation. Fe^{3+} is least suitable because it is usually accompanied by some Fe^{2+} whose absorption band near 1 μm induces color. Ti^{4+} was found to be best[6] because it introduces no absorption in the visible nor near infrared. As early as 1965, Kreidl et al.[4] affected dispersion by introducing cerium and recommended this technique for tailoring partial dispersion. The absorption edge of cerium is near 4 μm and may induce a slight yellow coloration.

To produce additional absorption bands, vibrating molecular groups would have to be introduced which will affect structure, uv absorption, and the location and intensity of the ir bands of the base glass. It is, therefore, difficult to predetermine the influence of added centers. For contemporary ir optics, however, a large variety of components affecting the ir edge are available.

Optical Glasses with Anomalous Partial Dispersion: The progress in high-quality optics achieved by the use of crystals with extreme partial dispersions has been known for a long time. The associated disadvantages such as cleavage in preferred direction, poor chemical resistivity, birefringence, low hardness, high cost, and so on had to be accepted in view of their favorable optical properties. In the past year a trend toward the development of glasses of equal or better partial dispersions than those of these crystals has been successful.

Besides a cruder characterization of optical glasses by their location in the $n_e - v_e$ diagram, it was Abbe who provided a finer characterization based on their partial dispersion behavior. For most glasses, Abbe's relation

$$P_{1,2} = a_{1,2} + b_{1,2} v_e$$

$$a_{1,2}, b_{1,2} \text{ constants, } v_e \text{ Abbe number} = \frac{n_e - 1}{n_{F'} - n_{c'}}; P_{1,2} = \frac{n_g - n_{F'}}{n_{F'} - n_{c'}}$$